the approach ideal for high-end audio product designs. Actual performances will mainly depend on the degree of matching among the active elements, especially Q1 and Q3. For optimum results, these two transistors should be a monolithic pair.

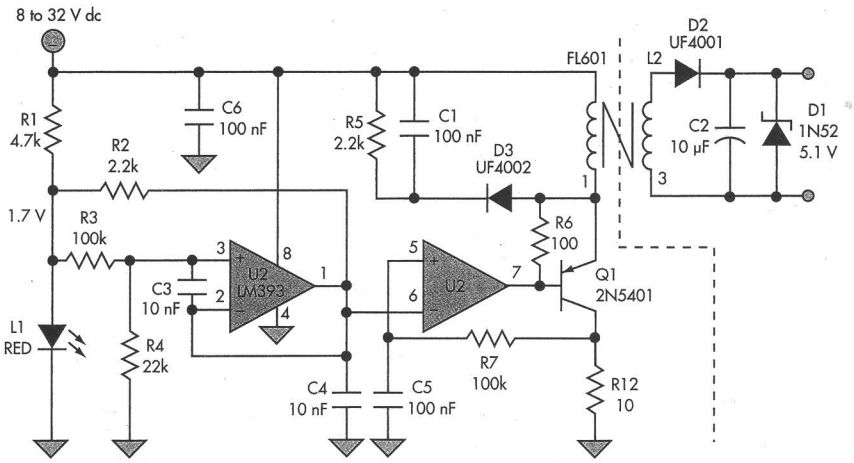
At the very least, they should closely match parametrically and be in thermal contact to match environmentally. Bias voltages influence the second-order compensation and may need adjustment according to the device type and geometry.

DWAYNE REID | TRINITY ELECTRONICS SYSTEMS, EDMONTON, CANADA dwayne.reid@trinity-electronics.com

Build Your Own Ultra-Low-Cost Isolated DC-DC Converter

WHEN LOW COST in small volumes using readily available parts is a primary concern, standard approaches to isolated dc-dc conversion may not be suitable. Integrated switchers from Linear Technology, Maxim Integrated Products, National Semiconductor, or Texas Instruments typically do not provide isolated outputs and so require expensive transformers that are hard to acquire in small volumes. Further, they typically require an opto-isolator and associated drive circuitry to provide feedback from the isolated output to the switch-mode controller.

An alternative using discrete components can provide 50 mA at 5 V from a dc input between 8 and 30 V dc *(see the figure)*. To avoid the need for feedback components, the power stage uses a constant current source design. This allows a shunt, such as the TL431 or even a simple zener clamp, to provide output voltage regulation.



Dual comparators act as a low-cost dc-dc converter with a simple common-mode choke serving as the isolation transformer.

Because the desired output voltage is less than the minimum input voltage, a simple 1:1 output transformer can provide the needed isolation. Low-cost, common-mode chokes can serve as the transformer. They have low capacitance between windings and excellent high-voltage isolation between the windings and cost only about $0.25 in quantities of hundreds.

A dc-dc converter requires a ramp generator and a comparator driving a power stage. Current feedback comes from a resistor in series with the transformer's primary winding. It's easy to make a ramp generator from an operational amplifier with some resistors and a capacitor. To save component count, however, the second half of the LM393 dual comparator replaces the op amp. A symmetrical ramp will work just fine, so there is no need for steering diodes. The ramp's maximum duty cycle is set to about 50% to reduce the chances of saturating T1.

To drive the chosen transformer with current-mode feedback and achieve minimum loss due the current sampling, the ramp generator needs to run at about 400 kHz with an amplitude of about 0.5 V. The exact amplitude and frequency needed depend on the reference. An ordinary red LED has a forward voltage that is reasonably constant over indoor temperature ranges, so it serves as a low-cost reference.

The pulse-width modulation (PWM) comparator does not have the current capacity to drive the transformer directly. Its open-collector output, though, allows the use of a PNP transistor (Q1) and a single resistor (R12) to act as the power stage. The circuit also acts as a high-voltage clamp. When a transient spike exceeds the comparator's breakdown voltage, the transistor conducts and clamps the spike.

Although the design is completely unorthodox, it works well and Spice simulations match the bread-boarded results. And, it's extremely low cost. Total parts cost in hundreds of units, including the transformer, is about $0.60.

DWAYNE REID has been manager of R&D at Trinity Electronics Systems Ltd. since 1984. He has been designing analog and digital systems for a variety of broadcast, interactive exhibit and industrial manufacturers since 1976.